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Vladyková, Petra; Rode, Carsten; Pedersen, Søren; Nielsen, Toke Rammer

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Passive Houses in Arctic.

What buildings should we build in Arctic?

Petra Vladykova, Ph.D. Student, pev@byg.dtu.dk; Søren Pedersen, PassivhusDK, sp@passivhus.dk

Introduction

The Passive house was designed and successfully implemented in Germany and other European countries as a highly insulated, air-tight, and healthy construction where thermal comfort can be achieved solely by post-heating (post-cooling) of the fresh air mass.

Passive House- functional definition

The fundamental concept of delivering all space heating just by heating the fresh air (no conventional active heating) [www.passivhaustagung.de 2008] can only work if even the highest immediate heat demand is very low.

Definition of Arctic

By *Polar Circles* (Arctic and Antarctic, at 66°33´38" Northern respectively Southern latitude); *treeless zone of tundra* and the regions of *permafrost* in Northern Hemisphere with average daily summer temperature <10 °C, and the soil is < 0 °C for two or more years.

The influence of the climate documents a Passive house Darmstadt-Kranichstein, which in German climate (longitude 9.57° E, latitude 39.48°) reaches a space heating demand of 14 kWh/(m²·a) and heating load of 10 W/m². When placed in Sisimiut, Greenland (old name: Holsteinborg, longitude -53.40° E, latitude 66.55°), the specific space heat demand raises up to 52 kWh/(m²·a) and heating load is 21 W/m². In order to reach the same space heat demand and heat load in Sisimiut, it would take increased insulation thickness etc.:

Kranichstein	Darmstadt, Germany	Sisimiut, Greenland
Wall insulation	275 mm with λ=0.040 W/(m·K)	600 mm with λ=0.033 W/(m·K)
Roof insulation	400 mm with λ=0.040 W/(m·K)	800 mm with λ=0.040 W/(m·K)
Floor insulation	250 mm with λ=0.040 W/(m·K)	400 mm with λ=0.040 W/(m·K)
Windows	U_g=0.7 W/(m²·K) U_f=0.59 W/(m²·K) g=0.5	U_g=0.33 W/(m²·K) U_f=0.36 W/(m²·K) g=0.39
Heat recovery efficiency	83%	92 %
Window area to TFA	28%	18%

Fig: Passive House Kranichstein construction for Germany and Greenland

Importance of circumstances – internal gains

The internal heat gains are important factors in Passive houses. In e.g. Greenland different circumstances might justify a different number for the internal heat gains:

- *dwelling area per person* is significantly smaller, thus internal heat loads are distributed on less area.
- smaller dwelling area means that *ventilation per area ideally is higher*
- need for *artificial lighting* might be different,
- *different use patterns* – are people in Greenland more or less indoor at home?
- different *expectations* for indoor climate – thermal indoor comfort versus adaptive thermal comfort

Different sources already claim different numbers for the *internal heat load*, varying from 2 to 8 W/m².

Internal heat gain	Germany	Greenland
Household appliances	0.651	1.060
People	1.073	1.747
Cooking	0.174	0.283
Lighting	0.171	0.278
Total	2.069	3.368

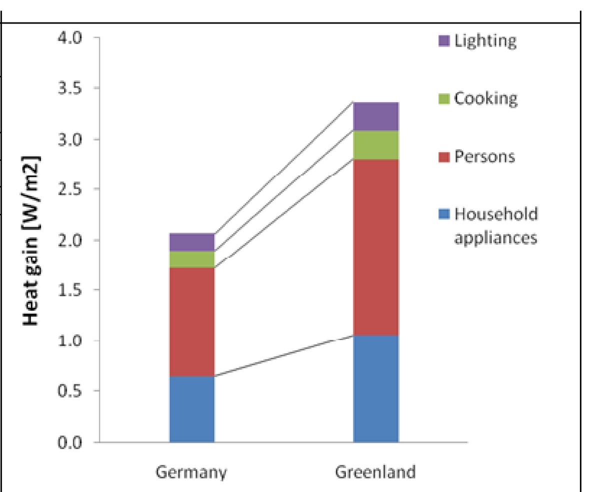

Fig: Internal Heat Gains in W/m² for Germany and Greenland

Fig: Arctic definition and Ittoqqortoormiit, settlement in Greenland

Alternative optimisations

Passive house is in principle possible everywhere and for Arctic the super-insulated, air-tight building with efficient heat recovery system is the most suitable and energy efficient structure. But it will not be probably the most optimal concept, regarding insulation level and payback time for saved energy considering current low energy prices.

Therefore more pragmatic solution is needed for Arctic with focus on following aspects:

- The Passive House in Arctic *as a whole system* – including energy supply and distribution, hydro power, geothermal and wind energy.
- The bigger differences such as *cultural and social*.
- Use of *fresh air heating paired with conventional type* of heating.
- Using *optimum of insulation and best available Passive House components*.
- Design of clever and compact structure with *minimized transmission losses* and *maximized solar and internal gains*.
- Aspect of thermal indoor comfort versus adaptive thermal comfort.

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